November 1988

DCIEM No. 88-TR-54

HUMAN FACTORS EVALUATION OF A NIGHT OBSERVATION DEVICE LONG RANGE

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
METHOD	
Subjects	1
Equipment	1
Target Detection Task	1
Training Procedure	2
Test Procedure	2
1. Compatability	2
2. Displays and controls	2
3. Operation	2
4. Assembly and disassembly	3
5. Effect on night vision	3
6. Acoustic detectability	4
RESULTS and DISCUSSION	
1. Compatability	4
2. Displays and controls	5
3. Operation	5
4. Assembly and disassembly	6
5. Effect on night vision	8
6. Acoustic detectability	8
CONCLUSIONS	13
RECOMMENDATIONS	13
REFERENCES	14

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ABSTRACT

A limited human factors evaluation was performed on a Night Observation Device Long Range (NODLR). This included compatability with personal equipment, assessment of controls and displays, ease of operation, time to assemble and disassemble, effect on night vision, and acoustic detectability. Military personnel acted as subjects for these trials. Subjective assessments of the equipment were made in addition to recording timings for the operation and assembly tasks. Some displays and controls were found to be difficult to use. The equipment was found to be acoustically detectable beyond the standard of 30 metres and assembly of the complete system was very time consuming owing to a number of design faults.

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INTRODUCTION

DCIEM was asked by DLAEEM 4-3-5 (1) to conduct a human factors evaluation of a Night Observation Device Long Range (NODLR). The equipment (details below) to be tested was a prototype, manufactured by SPAR AEROSPACE Ltd. It was delivered on 22 April 1988 and a short demonstration was given by DLAEEM. As the equipment was due in Gagetown for a user trial the following week, DCIEM had only five days in which to complete the evaluation. The details of this evaluation are given below.

METHOD

The following aspects of the NODLR system, derived from the human factors requirements identified in the system Statement of Requirements (SOR) were examined:

1. Compatability with personal equipment
2. Displays and controls
3. Operation
4. Assembly and disassembly
5. Effect on night vision
6. Acoustic detectability

Aspects 1, 2 and 3 were evaluated by observing performance of subjects on a target detection task (detailed below). The same subjects were used in the evaluation of aspects 4 and 5. Measures of acoustic detectability (Aspect 6) were made without subjects.

Subjects - Four male military personnel were used as subjects for the evaluation. Subjects ranged from 167 to 185 cm in height. All were right-handed and none wore glasses. Visual acuity was not tested. Only one had previous experience with night observation devices. Subjects were tested individually and were asked not to discuss their experiences with the others.

Equipment - The following equipment comprised the complete NODLR system provided to DCIEM:

1 NODLR with rubber eyecup
1 laser range finder (LRF)
1 goniometer (gonio)
1 tripod
1 battery pack and cord
2 spare batteries
1 AC/DC power supply unit and cord
1 monitor lead
2 carrying cases

The system was operated throughout the evaluation using the AC/DC power supply unit. The use or changing of the batteries was not tried. The rubber eyecup provided was used throughout the evaluation.

Target Detection Task - In order to obtain information on ease of operation of the NODLR as well as compatability with equipment, some form of detection task was needed. As DCIEM does not possess specialised equipment tc test thermal imagers, or access to a range with real targets (heat sources), a simple apparatus was designed to simulate heat sources. The target consisted of a row of 3 to 5 small light bulbs which acted as the heat sources for viewing by thermal imagery. The bulbs were driven in parallel by a 6 volt

battery with a maximum output of 1.0 watts per bulb. In order that they were visible through the NODLR at the limited range available in the experiment room, they were spaced horizontally along a bar which was suspended 1.25 m above ground and 8 m from the centre of the NODLR tripod. Spacing between bulbs was measured from the centre of each filament. In preliminary tests, the spacing was set at 1.5 cm which was above the threshold of resolution for three experimenters who had gained some experience in operating the equipment. This spacing was used for the first subject but was increased to 2 cm for subsequent subjects. The subjects' task was to acquire the target (which was hidden from the naked eye) and resolve the number of heat sources (bulbs) as quickly as possible.

Training Procedure - The subjects were all trained on the target detection task prior to testing. The manual mode was used because it was less difficult to use than the automatic mode. During the training period, the controls were explained and their effects demonstrated. Two heat sources were presented and the display shown to the subject to familiarise him to the stimuli. The *gain* and *level* controls were then set fully counter-clockwise and the *focus* to its minimum (closest) range as a starting point. Subjects were then instructed to find the target again. As this was the training period, help was given until the subject and experimenter were reasonably confident about the operation of the equipment. Due to time constraints, exhaustive training could not be given.

Test Procedure - The subjects' task was to acquire the target and resolve the number of heat sources (bulbs) as quickly as possible. Each subject performed the task three times, once with each of the three clothing assemblies (detailed below). If the subject did not give the right answer initially, he was intructed to try again. The clothing assembly order and number of heat sources (3-5) were balanced across the subjects. For each trial, time to identify the number of heat sources was recorded.

1. Compatability

The subjects wore the following clothing assemblies when operating the NODLR:

Combat assembly - Steel helmet and leather combat gloves.
Arctic assembly - Steel helmet and Trigger Finger Mitts (TF mitts), with wool liner.
NBC assembly - Steel helmet, C4 respirator and NBC gloves.

After undertaking the task in each of the assemblies, the subjects were asked to comment on how easy or difficult the task was. Comments were recorded.

2. Displays and Controls

The displays and controls were examined throughout the trials by both the experimenters and the subjects. Comments were noted and are detailed in the Results Section.

3. Operation

The operation of the NODLR was evaluated while undertaking the compatability assessments. A video recording (detailed below) from the NODLR test port which showed what the subject saw through the eye cup was also used in the assessment.

4. Assembly and Disassembly

Subjects were trained to disassemble and assemble the NODLR equipment set up in the following format:

Tripod
Goniometer
NODLR
Laser Range Finder (LRF)
Power cord

Subjects wore leather combat gloves while disassembling and assembling the equipment in the light. This was treated as a training session, and was videotaped. The subjects were then required to disassemble and reassemble the equipment in the dark while wearing TF mitts. They were first dark adapted for 10 minutes in a dark room where the light level was less than 1/10 lux. This equates to moonlight. Time to disassemble and then reassemble each component was recorded. As soon as reassembly was complete, the NODLR was powered up and the subject instructed to acquire and resolve the number of heat sources.

The effect of using the NODLR on night vision was evaluated at the same time as this last assessment but light levels in the room had to be increased to undertake the testing. Details are given in Section 5.

Video recording - During the assessments of Aspects 1 to 4 listed above, two video recordings were made. A video camera unit was used to record the subject operating the equipment, and a second video recorder was connected directly to a video monitor which was connected to a test port on the NODLR equipment. This showed what the subject was seeing on the NODLR visual display. The two recordings were synchronised using a time coding imposed on the tapes.

5. Effect on Night Vision

DCIEM does not have test equipment to evaluate effects of display lighting on night vision. However, an attempt was made to assess the effect of the NODLR on night vision by using a test of visual contrast sensitivity (CS). It should be noted that the CS test was not originally designed for use in low light levels. CS tests measure the subject's ability to detect luminance differences (contrast) in a visual pattern. The patterns used in the CS tests normally appear as a series of light and dark bands (sine-wave patterns) of various frequencies (widths).

Vistech 6500 CS test charts were used to test CS at five spatial frequencies, ranging from 1.5 to 18 cycles per degree (cpd). In this test, subjects are presented with a series of patches containing the contrast patterns. The patches are read across the charts in order of decreasing contrast. The subject is asked to determine the orientation of the bars until the contrast is so low that they cannot be seen. The contrast level of the last patch correctly read is used to determine the score at each frequency.

Prior to testing, subjects were dark-adapted for ten minutes. The tests were performed at a room illumination level of 1 Lux, as it was found that this was the lowest light level at which any patches on the charts could be read. Subjects were tested individually, once before using the NODLR and once after exposure to a 'white-out' on the display. This condition, which caused the greatest increase in display luminance, was achieved by changing the viewing polarity. It was felt that any decrement in CS scores from the first to second test would indicate that the display brightness could possibly have a detrimental effect on night vision. Throughout these assessments, a Hagner Universal Photometer

(Model S2) was used to measure both the illuminance in the room and the luminance of the display.

6. Acoustic Detectability

According to the SOR, the NODLR should not be detectable beyond 30 m. In order to evaluate this, the method and guidelines proposed by Human Engineering Laboratories (HEL) (2) were used. The DCIEM reverberant chamber was used for the assessment and was converted into a semi-anechoic chamber by positioning vertical acoustic screens around the equipment and sound level meter area with blankets covering the floor. The noise floor of the area was checked to ensure it was at least 10 dB below the noise of the NODLR equipment and the HEL guidelines in every one-third (1/3) octave band.

Recordings of the noise emitted from the NODLR were made during the following conditions: normal operating (OPERATION), the cool-down period (COOL-DOWN) and the power switch on (SWITCH). These measurements were made with a sound level meter (B&K 2230) connected to a tape recorder (NAGRA SJ). The meter was positioned 1.2 m above the ground and 2 m from the NODLR. The recordings were analysed in terms of LEqs using the sound level meter fitted with 1/3 octave filters. The results are compared to the 'typical aural nondetectability limits' which is not the quietest spectrum quoted in the guidelines.

RESULTS and DISCUSSION

1. Compatability

In an attempt to provide a measure of the relative difficulty of operating the NODLR while wearing different clothing assemblies, subjects performed the target detection task. The time taken to resolve the target was recorded for each trial. As shown in Table 1a, times varied widely across subjects and clothing assemblies. Subject 1, who was working on a target with lights 1.5 cm apart, was never able to answer correctly on the first attempt. For the other subjects, times for a correct response on the first attempt ranged from 34 to 128 seconds. Only once did a subject (apart from subject 1) have to make a second attempt to answer correctly.

No consistent differences in acquisition and resolving times were apparent across the clothing assemblies. Nor was there a consistent training effect as seen by comparing the order of presentation from Table 1b with times from Table 1a.

A summary of subjects' comments on compatability problems are given below.

> Combat assembly - No compatability problems were encountered with the Combat assembly.
>
> Arctic assembly - When using the TF mitts, subjects found it difficult to use the touch sensitive focus pads as they could not 'feel' the activation of the focus control. The reticule was also switched off accidentally by one subject. It was suggested that higher ridges between control pads would help location and retention of finger position.
>
> NBC assembly - One subject reported that when wearing the C4 respirator, the view of the display was restricted. Not all the 'flags' could be seen.

Table 1a. Time to resolve target while wearing different clothing assemblies

Subject	Try	COMBAT Time (sec)	Lights	Answer	ARTIC Time (sec)	Lights	Answer	NBC Time (sec)	Lights	Answer
S1	1	108	4	2	66	5	2	85	3	2
	2	33	4	4	171	5	3	-		
S2	1	98	5	5	42	3	3	128	4	4
S3	1	34	3	3	47	4	4	86	5	5
S4	1	70	4	2	46	5	5	55	3	3
	2	16	4	4						

Table 1b. Order of Condition Presentation

S1	3	2	1
S2	1	3	2
S3	2	1	3
S4	3	2	1

2. Displays and Controls

'WARM' Flag - When the NODLR is in the cooling down phase, the flag on the display reads 'WARM'. This is confusing to the user, especially if he is not aware that the device has to cool down before it is usable. It is suggested that a more suitable flag would be 'WAIT'.

Focus - The focus adjustment takes up to 18 seconds to go from one limit to another. This may well be considered too long under operational conditions. To overcome the problem, a coarse and fine adjustment could be provided. Apart from the 'FLIM' at either end, there is no indication for the user as to where the focus is set relative to those limits. It is suggested that a sliding scale should be shown, indicating where the focus is set relative to its limits.

Power Switch - This is located too close to the power cable connection which makes connecting the cable or operating the switch difficult, especially when wearing gloves. The three positions of the switch are also not labelled, making it difficult to tell which position the switch is in.

3. Operation

Initially, the instructions provided by the manufacturer for detecting targets were followed. However, this method led to the targets not being found in the training session and taking considerable time in the case of Subject 1 (who, as previously noted, was presented with a more difficult target than the other subjects). The method suggested as a result of the trials was to set the *gain*, *level* and *focus* to around the mid point and then manipulate one or more to acquire the targets. The SOPs included in the training and operating manuals should be tried and tested prior to publication to ensure that the operators can use the NODLR satisfactorily if they follow these instructions.

Although the task did not give quantitative results, it did highlight operating and compatability problems within the confines of what was asked of the operators. No attempt was made to boresight the equipment and it is realised that the trials were limited in their assessment of all NODLR functions and capabilities. It was suggested, as a result of the operating problems found, that the trials at Gagetown include targets at different ranges and intensities unknown to the operator to determine whether there are any detection problems.

4. Assembly and Disassembly

Table 2 gives the times taken to assemble the system in the dark. Table 3 gives the times taken to disassemble the system in the dark.

Table 2. - Time (secs) taken to assemble NODLR in the dark

	SUBJECT					
	1	2	3	4	Mean X	CL ±
TRIPOD	69	96	45	58	67	22
GONIOM. *	143	63	191	108	126	55
NODLR	78	94	80	142	98	30
LRF	228	98	>300	>300	N/A	N/A
POWER CORD	33	45	8	173	65	75
Total time#	551	366	637	768	N/A	N/A

* This time includes an attempt to level the goniometer on the tripod.
# Total time taken to assemble equipment
N/A - Mean (X) are not given as distribution is not normal
CL - 95 % confidence limits

Table 3. - Time (sec) taken to disassemble NODLR in the dark

	SUBJECT 1	2	3	4	Mean X	CL ±
POWER CORD	N/O	N/O	7	5	N/A	N/A
LRF	18	17	13	13	15	3
NODLR	22	28	61	11	30	22
GONIOM.	18	15	15	7	14	5
TRIPOD	33	31	50	40	38	9
Total time *	91	91	139	71	98	29

* does not include time taken to remove power cord.
N/O not observed.

Tripod - All subjects found the tripod difficult to adjust. Also, it cannot be adjusted to provide a stable platform that is low enough to achieve the prone position when viewing. It is also difficult and dangerous trying to adjust the tripod with the weight of the equipment on it. It is realised that this is not normal practice, but it may be necessary in some circumstances. It is suggested that a wind up/down mechanism be used.

Goniometer - The movement of this is too free with the weight of the NODLR on top, even in the damped condition.

NODLR - The release mechanism of the retaining mount is difficult to locate and to operate, especially with TF mitts. It is suggested that a less complicated device be designed, without the small bar.

LRF - Mounting this on the NODLR presented problems. Table 2 shows that, for two subjects, the task was aborted after 5 minutes of trying. Gloves get caught in the release levers, the lever spring is too strong, and the pins on the LRF mount are difficult to match with the holes in the NODLR mount. The ridged slope on the mount is more a hindrance than a help. It was noticed that trying to mount the LRF on the NODLR was an extremely noisy procedure, especially as the two surfaces are bare metal. This mount should be completely redesigned with a more positive keying device.

Power cord - In some instances, the power plug took a long time to connect to the socket as it is positioned too close to the power switch, allowing little room for hands with gloves on.

Assembly time - The total assembly times given in Table 2 seem to be excessive, in that they range from 6.1 minutes to 12.8 minutes. This does not include unpacking the device or setting up the batteries. The operational implications of this delay must be assessed by the user. However, it is expected that assembly time would decrease with practice.

5. Effect on Night Vision

When tested for CS prior to using the NODLR, all subjects had very similar results for CS at 1.5, 3 and 6 cpd. Two subjects could determine the orientation of a test patch at 12 cpd, and none could at 18 cpd. When re-tested after exposure to the maximum display brightness (45 candelas/m2) there were no meaningful shifts in scores. Most of the scores remained the same, while others shifted up or down by one contrast level only.

The results may indicate that the CS test performed prior to exposure to the NODLR display was at too high a light level, and night vision had already been lost. It is more likely, however, that the CS test was not sufficiently sensitive to detect the effect of display brightness on night vision. Given the brightness level of the display, some loss of night vision can be anticipated. A better estimation of the extent of this loss would require the use of a more sensitive test.

6. Acoustic Detectability

Results from the three conditions, 'OPERATION', 'COOL-DOWN' and 'SWITCH' are shown in Table 4. Levels in any 1/3 octave band should not exceed those given in the HEL guidelines (HEL).

TABLE 4. NODLR noise spectra

Frequency 1/3 octave	HEL dB	OPERATION dB	COOL-DOWN dB	SWITCH dB
125	51	28	30	33
160	48	25	27	24
200	51	26	28	31
250	53	26	27	25
315	54	26	29	28
400	50	26	33	35
500	54	37	38	39
630	54	48	49	46
800	47	46	50	48
1000	42	45	49	49
1250	39	46	54	46
1600	35	45	56	50
2000	32	49	51	53
2500	31	43	55	53
3150	34	42	48	54
4000	34	38	49	53
5000	25	39	47	53
6300	30	42	54	51
8000	39	35	48	49
10000	42	31	39	43

_ denotes levels that exceed the HEL guidelines.

All conditions tested exceed the HEL guidelines from around 800 Hz to 8000 Hz. The spectra are plotted in Figures 1 to 3.

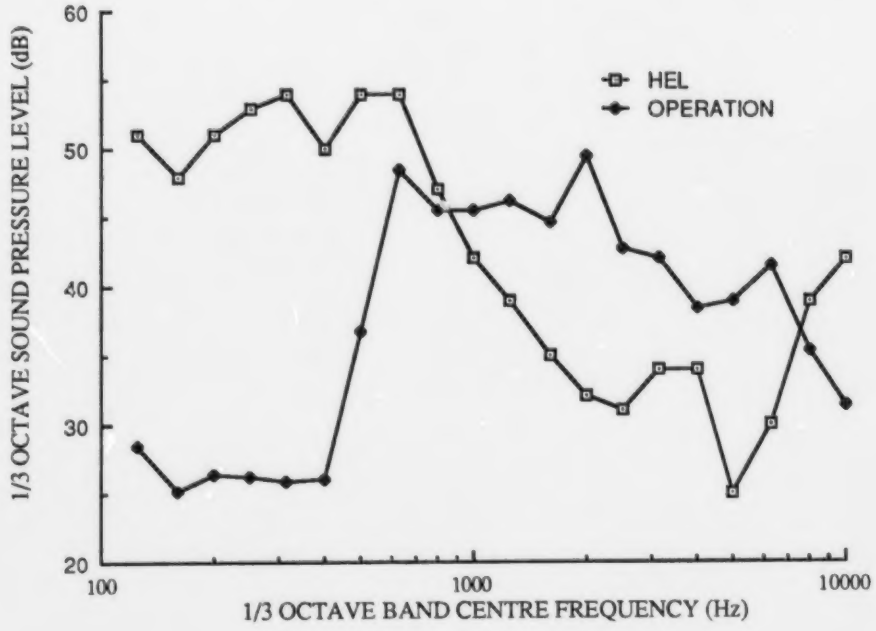

Figure 1. Noise spectrum from NODLR operation

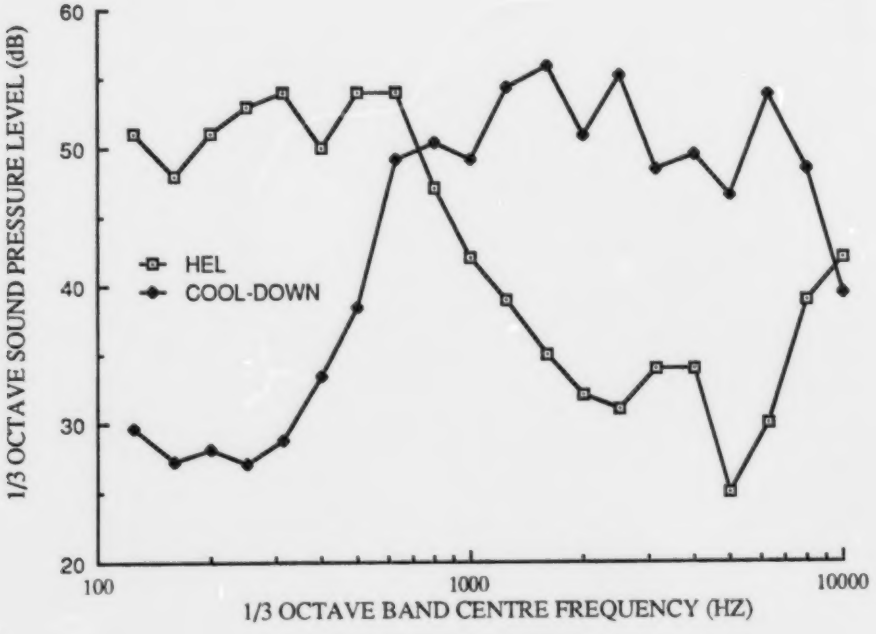

Figure 2. Noise spectrum from NODLR cool-down

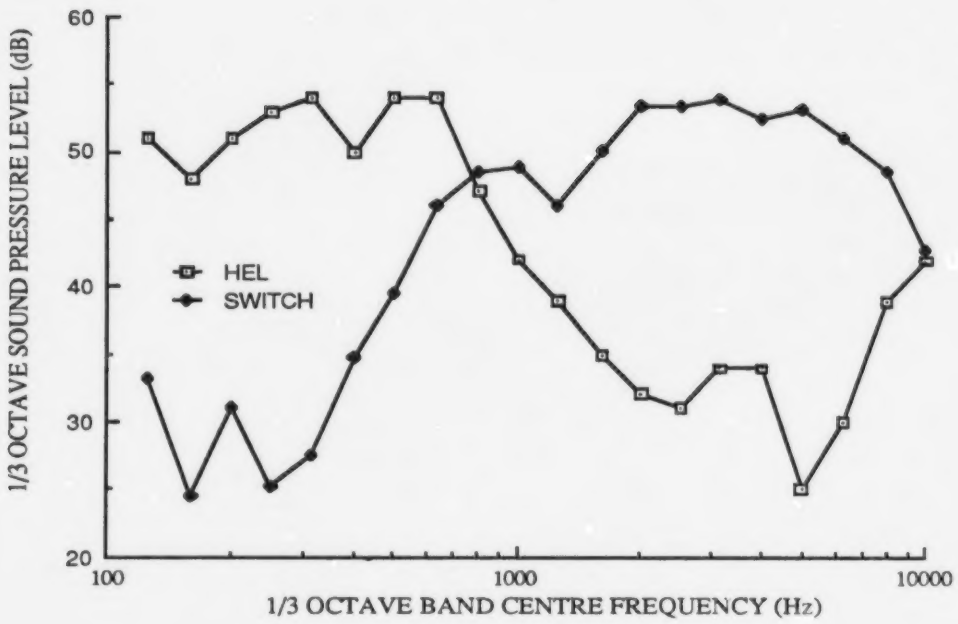

Figure 3. Noise spectrum from NODLR power switch

After the results had been analysed this way, DLAEEM requested that the NODLR noise spectra be compared to MIL STD 1474A(MI) (3) as this was the standard that the manufacturer had used. The 1/3 octave bands were converted into octave bands and are expressed against both standards in Table 5.

TABLE 5. Comparison of NODLR noise against HEL and MIL STD 1474A(MI)

FREQUENCY Octave	HEL dB	1474 dB	OPERATION dB	COOL-DOWN dB	SWITCH dB
125	58	45	31	-	-
250	58	43	31	33	33
500	58	43	49*	50	47*
1000	49	43	51*	57*	53*
2000	38	44	51*	59*	57*
4000	37	44	45*	53*	58*
8000	44	45	43	55*	54*

_ (underline) denotes noise in excess of HEL guidelines

* (asterisk) denotes noise in excess of MIL STD 1474A(MI).

In this instance, MIL STD 1474A(MI) is the more stringent standard in that it extends the significant frequencies down to 500 Hz from 800Hz. The HEL guidelines should be used when possible as the methodology is more comprehensive and the limits proposed are based on more recent data. Figures 4 to 6 show the NODLR noise spectra plotted against both the HEL guidelines and MIL STD 1474A(MI). It is clear that by any standard the NODLR system will be detectable beyond 30m.

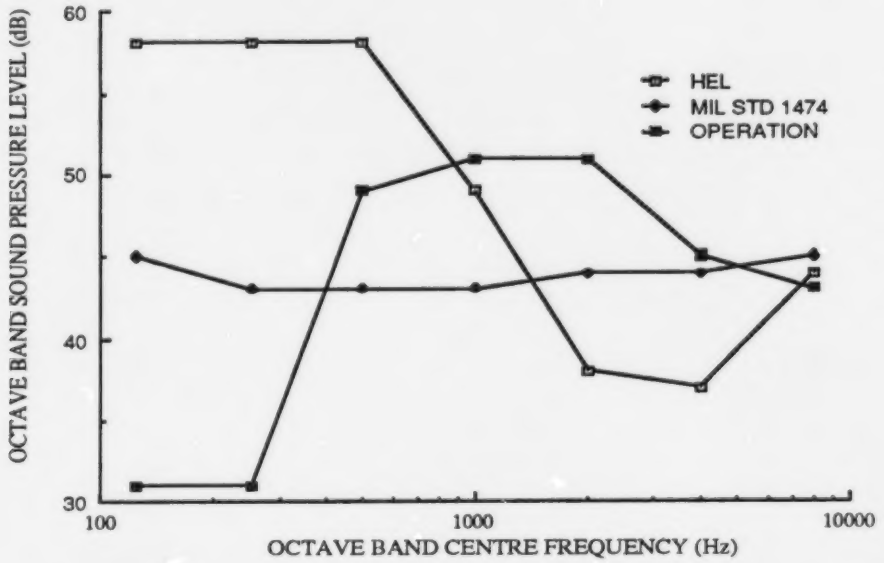

Figure 4. Comparison of detectability standards against NODLR 'operation' noise

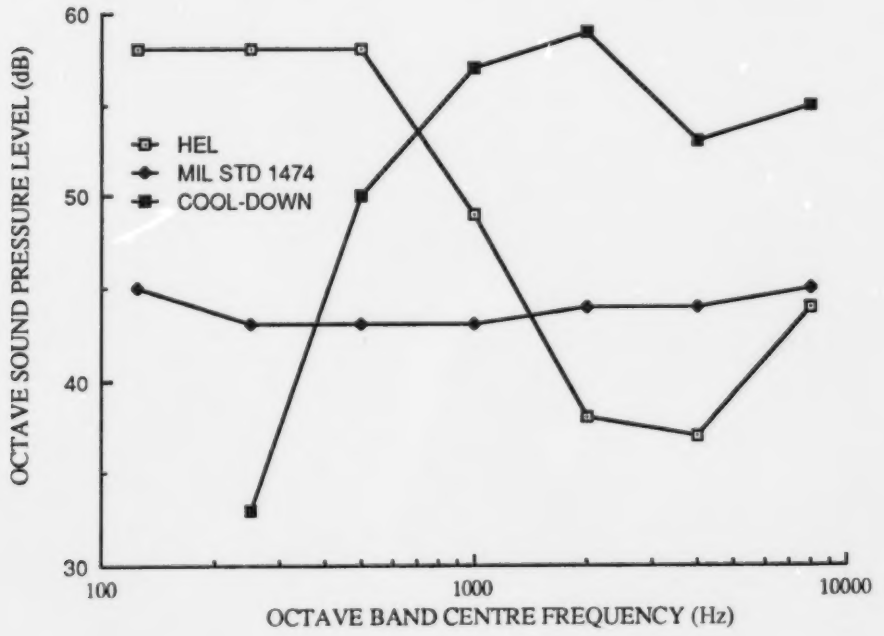

Figure 5. Comparison of detectability standards against NODLR 'cool-down' noise

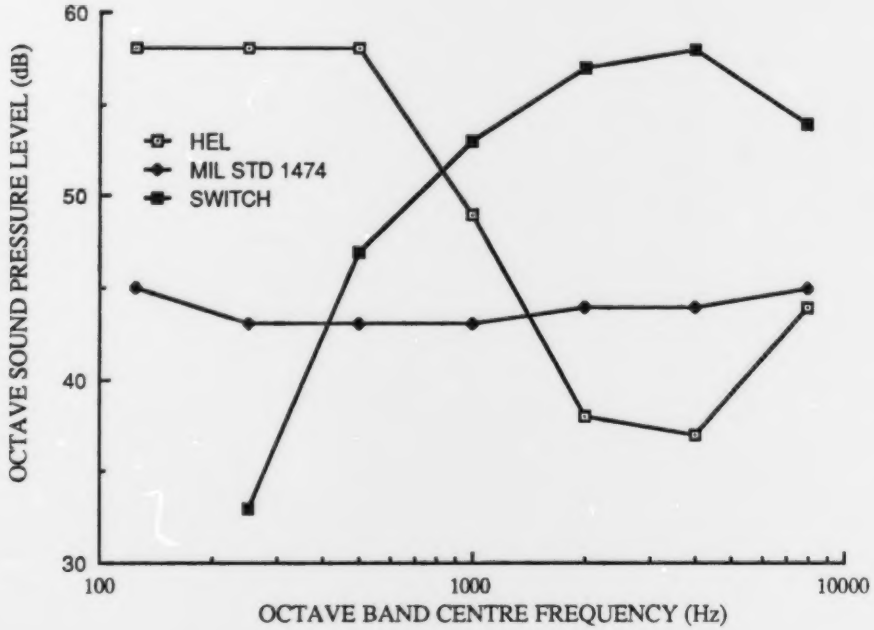

Figure 6. Comparison of detectability standards against NODLR 'power switch' noise.

CONCLUSIONS

A limited number of human factors aspects of the SPAR NODLR system were assessed. Time constraints did not permit a full and detailed evaluation to be undertaken. Conclusions about Aspects 1 to 5 were drawn on the basis of four subjects with limited training.

1. Compatability -
The view of the display may be restricted when wearing the C4 respirator and the TF mitts reduce the feedback from touch pad controls leading to errors in locating controls. Other equipment tested did not present compatability problems.

2. Displays and Controls -
The 'Warm' flag which indicates a unready condition, is confusing to the operator. Focus adjustment takes too long to achieve and no feedback is available to the operator as to the position of the focus relative to its close and far limits. The power switch is located too close to the power cable connection, making its operation difficult. In addition, the three positions of the switch are not labelled.

3. Operation -
From the results of both the training session and the target detection task, it can be concluded that the manufacturer's instructions for operating the NODLR need to be improved.

4. Assembly and Disassembly -
The tripod was difficult to adjust, too high to be used for prone viewing, and unstable during adjustment. The goniometer moves too freely. The NODLR mount mechanism onto the goniometer is difficult to locate and operate, and mounting the LRF onto NODLR is both difficult and noisy. Overall assembly time appears to be excessively long

5. Night Vision -
It is likely that the contrast sensitivity test was not sensitive enough to measure any effect of NODLR on night vision.

6. Acoustic Detection -
The NODLR fails both the HEL and the MIL STD 1474A(MI) detectability standards and therefore will be detectable beyond 30 m, which is unacceptable.

RECOMMENDATIONS

1. Investigate restriction of display view by C4 respirator. Modify touch sensitive pads and raise dividers on control panel to provide more positive feedback and easier location of controls.

2. Change 'Warm' flag to 'Wait'. Modify focus controls to provide faster adjustment and more positive feedback. Provide indicator of relative position of focus.

3. Investigate possible improvements to instructions and training protocols.

4. Modify or replace tripod, improve goniometer damping mechanism and redesign mounts for both the NODLR-goniometer and the LRF-NODLR interfaces.

5. Investigate the effect of NODLR displays on night vision, using equipment designed for testing night vision.

6. Reduce the noise from all NODLR operations.

ACKNOWLEDGEMENTS

The authors acknowledge the assistance of Brian Crabtree in the acoustic trial, and the advice from Sharon McFadden on visual aspects of the trial.

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Human Factors Evaluation of a Night Observation Device Long Range

4. AUTHORS (Last name, first name, middle initial. If military, show rank, e.g. Doe, Maj. John E.)

Rylands, Julia M.
Sutton, Kathleen M.

5. DATE OF PUBLICATION (month and year of publication of document)	6a. NO. OF PAGES (total containing information. Include Annexes, Appendices, etc.)	6b. NO. OF REFS (total cited in document)
November 1988	17	3

6. DESCRIPTIVE NOTES (the category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

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A limited human factors evaluation was performed on a Night Observation Device Long Range (NODLR). This included compatability with personal equipment, assessment of controls and displays, ease of operation, time to assemble and disassemble, effect on night vision, and acoustic detectability. Military personnel acted as subjects for these trials. Subjective assessments of the equipment were made in addition to recording timings for the operation and assembly tasks. Some displays and controls were found to be difficult to use. The equipment was found to be acoustically detectable beyond the standard of 30 metres and assembly of the complete system was very time consuming, owing to a number of design faults.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus. e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus-identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

night observation device
target detection
acoustic detectability
night vision
compatability
human factors
thermal imagery